Lesson 4 Overview

DRIVING QUESTION: *What is climate change and why does it matter?*

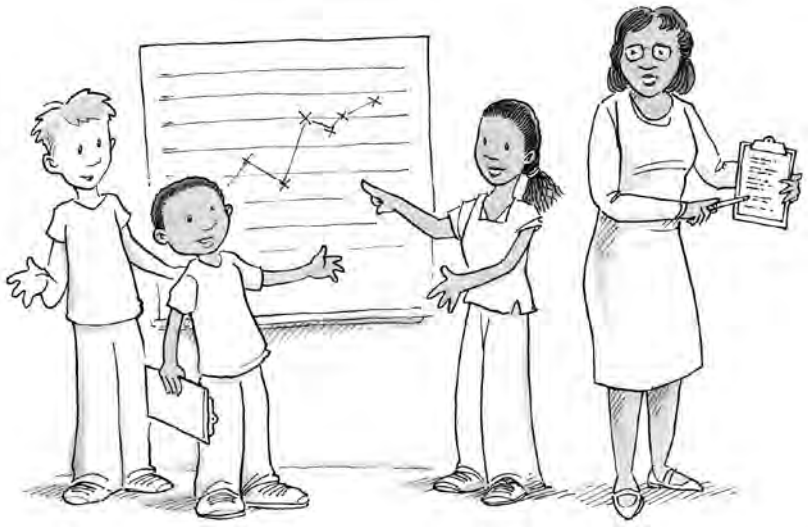
LEARNING GOALS:

- Analyze data to identify patterns of average temperature over the past 100 and 400 years.
- Create a scientific explanation about the difference between weather and climate for global temperature by answering the scientific question, "Is global temperature changing because of weather?"
- Use representations to investigate the impact of a degree change in temperature on Earth's processes.

TOTAL TIME: 220 minutes (approximately 4 class periods)

LESSON SUMMARY:

Students will understand the difference between weather and climate. They will analyze weather and climate temperature data to learn about global trends in temperature. Through a hands-on activity, students will see how small changes in global temperature can potentially have large impacts on the environment.



MATERIALS:

- *Stearic Acid Lab materials*
- *Water bath, thermometers, and beakers (3)*

BEFORE YOU BEGIN LESSON 4:

Part 1

	This lesson is split into three parts that exlore different aspects of weather and climate and of climate change. Part 1 deals with the difference between weather and climate, particularly from a data perspective. Students should learn that a single data point does not reveal a pattern. Rather, many data points taken together reveal patterns and trends.

Part 2

	In Part 2, students use real climate data to look at temperature trends over time. Using these data, students make general statements about climate and make a prediction about future temperatures.

Part 3

	In Part 3, students use a hands-on activity, the Stearic Acid Lab, to explore the impact of a few degrees change in temperature on a material. Please make sure to test the class demonstration and laboratory before your class to make sure you have all the necessary materials and are familiar with the laboratory processes.

Part 1: What can data tell us?

The purpose of this activity is to help students understand the difference between weather and climate through a sports analogy. This analogy will help students understand that one day of weather is not enough to characterize climate. Have students work in pairs or groups to answer the questions below. Next, discuss the answers as a class to talk about data, averages, and trends.

Lesson 4 Part 1: What is climate change and why does it matter?

What can data tell us?

In this activity, you will learn about the differences in how weather and climate are calculated. By analyzing statistical data from the 2011 season, you will see how one piece of data does not tell the whole story of a football team's success. Football data are used instead of weather data to illustrate the idea of long-term averages and trends.

Discussion Questions:

1. Based on the following ESPN NFL game scores, who seems like the better team?

Buffalo Bills

2. Based on the information from SportingNews NFL, what actually happened to each team by the end of the season?

The New England Patriots won more games in the season than did the Buffalo Bills.

3. How do we know from this data that overall, the Patriots had a better season than the Bills? What is the data, or evidence, for this claim?

The number of wins or losses over the season.

4. Why is a whole season necessary to determine a team's performance? Why not just have two or three games to show which teams are best?

Teams might win or lose a single game, but they are better teams if they win more games than they lose. So you need a whole season of games to know how they did.

5. Is the game data (from ESPN NFL game scores) not useful since it did not indicate the better team?

Game data tells you about that game, but not the season.

6. What are other analogies that you can think of where you cannot draw conclusions from small or incomplete pieces of data?

My dog usually catches his frisbee, but sometimes he doesn't. So one time that he doesn't catch the frisbee doesn't mean that he never catches the frisbee.

Part 1: What is the difference between weather and climate?

Students answer a set of questions about weather and climate before they read a NASA article.

What is the difference between weather and climate?

This activity focuses on two terms that you hear almost everyday: weather and climate. We often check the weather before we leave the house in the morning and hear information on the news about climate. How would you explain each term? Write a definition for each term below:

Weather:

Weather is what it's like outside right now.

Climate:

Climate is what it is usually like in my area at this time of year.

Now, let's see how close your definition is to the explanation that the National Aeronautics and Space Administration (NASA) uses. To understand how weather and climate are different, we need to know exactly what each term means. Read through the NASA article on page 7 of your student notebook, then answer the questions below:

Part 1: What is the difference between weather and climate?

Now that students understand the importance of collecting plenty of data before drawing conclusions, segue into the difference between weather and climate using an article by the Michigan Sea Grant: Weather and Climate: What is the Difference? (Page 7 of student notebook).

Reading: What is the Difference Between Weather and Climate?

Read the following excerpts from a NASA article. When you are finished, go back online to answer some questions about weather and climate.

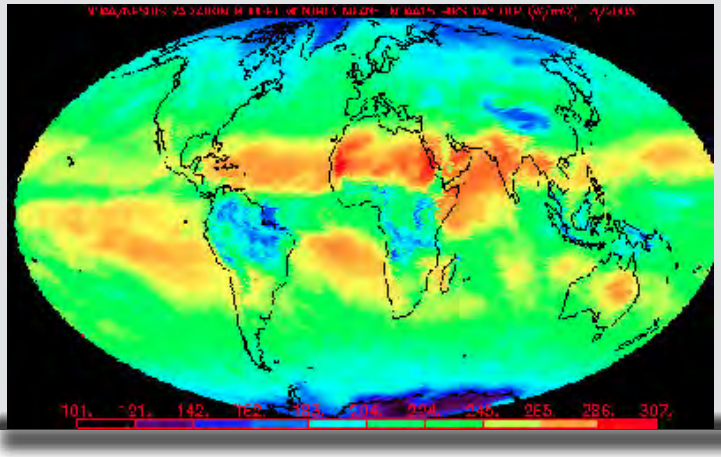
What weather means

Weather is basically the way the atmosphere is behaving, mainly with respect to its effects upon life and human activities. The difference between weather and climate is that weather consists of the short-term (minutes to months) changes in the atmosphere. Most people think of weather in terms of temperature, humidity, precipitation, cloudiness, brightness, visibility, wind, and atmospheric pressure, as in high and low pressure.

In most places, weather can change from minute-to-minute, hour-to-hour, day-to-day, and season-to-season. Climate, however, is the average of weather over time and space. An easy way to remember the difference is that climate is what you expect, like a very hot summer, and weather is what you get, like a hot day with pop-up thunderstorms.

Things that make up our weather

There are really a lot of components to weather. Weather includes sunshine, rain, cloud cover, winds, hail, snow, sleet, freezing rain, flooding, blizzards, ice storms, thunderstorms, steady rains from a cold front or warm front, excessive heat, heat waves and more.

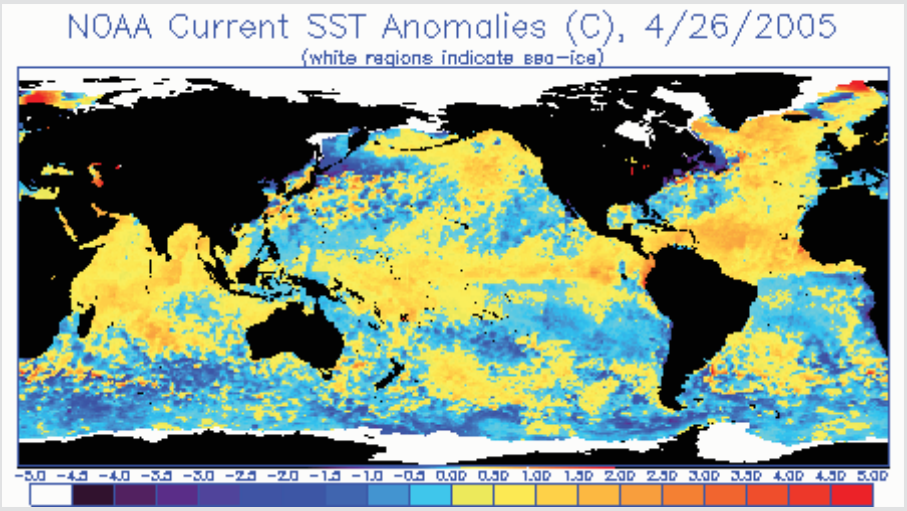


What climate means

In short, climate is the description of the long-term pattern of weather in a particular area. Some scientists define climate as the average weather for a particular region and time period, usually taken over 30-years. It's really an average pattern of weather for a particular region. When scientists talk about climate, they're looking at averages of precipitation, temperature, humidity, sunshine, wind velocity, phenomena such as fog, frost, and hail storms, and other measures of the weather that occur over a long period in a particular place. For example, after looking at rain gauge data, lake and reservoir levels, and satellite data, scientists can tell if during a summer, an area was drier than average. If it continues to be drier than normal over the course of many summers, than it would likely indicate a change in the climate.

What's the difference between weather and climate?

The difference between weather and climate is a measure of time. Weather is what conditions of the atmosphere are over a short period of time, and climate is how the atmosphere "behaves" over relatively long periods of time.



Article source: (http://www.nasa.gov/mission_pages/noaa-n/climate/climate_weather.html)

Part 1: What is the difference between weather and climate?

Students answer a set of reading comprehension questions after going through the NASA article.

Reading Check Questions:

1. How are NASA's definitions of weather and climate different from the ones you wrote?

They are mostly the same.

2. How would you describe the weather in your city today? How would you describe the climate in your region during this time of year?

Weather:

Today it is cloudy and cold, it was raining a little earlier.

Climate:

At this time of year it is usually sort of cold, although it can be sunny or cloudy.

As you saw in the reading, both weather and climate include multiple types of abiotic factors such as temperature, precipitation, and wind. In the next few activities, we are going to focus on one abiotic factor: temperature. There are several reasons for focusing on temperature:

- It is easy to measure
- There are lots of historical data
- It has direct impacts on where species and ecosystems are found.

Part 1: What is the difference between weather and climate?

Students begin to explore real climate and weather data to understand the differences and to understand how weather influences climate. In these activities, students calculate averages to understand how individual values (weather) can influence averages over longer periods (climate).

Let's start by looking at the temperature across various cities. First, we want to find temperature readings in your local area. Visit the Weather History page at Weather Underground. Type in your zip code or city name to find mean temperature (in Celsius) in your area and enter it here. (You may need to change between Fahrenheit and Celsius in the upper right corner of the webpage):

19.3

Next, find the mean (average) temperature for the same day (or closest day) for the previous five months, to give you a total of six values. Enter the values in the chart below. For example, if yesterday was June 1st, you would need to find the mean (average) temperatures for the five months before that, which is January 1st, February 1st, March 1st, April 1st, and May 1st – all in the same year.

Months	Date - Month and Day	Temperature (Celsius)
Current Month	October 5	14
Last Month	September 5	21
Two Months Ago	August 5	27
Three Months Ago	July 5	23
Four Months Ago	June 5	14
Five Months Ago	May 5	17

Calculate the average temperature of these 6 months, and write it here:

19.3

This is a current, 6 month average temperature for your city.

Part 1: What is the difference between weather and climate?

Students finish exploring weather data for their city, comparing a 6 month average with an average annual temperature.

Next, visit the Local Climate page. You will see a graph that shows the average local climate of your city for different years. With your mouse, *click inside* the graph until you see a red vertical line. Move the red line left and right. As you move the line, look *underneath* the graph to see changes in average temperature for different years. Move the line so it is *exactly* on the year 2010. Note the average temperature in *Celsius* for the year 2010, and enter it here:

10.2

This is the average annual temperature for your city in 2010.

Is the current, 6 month average temperature and average annual temperature of your city the same or different. Why do you think this is the case?

They are different numbers. They are different because one is a 6 month average in this year and the other is a whole year average for 2010

Part 2: Is average temperature changing over time?

Students look at climate over longer periods of time to explore patterns over time in recent history.

Lesson 4 Part 2: Is average temperature changing over time?

We will now look at how climate changes over a longer period of time. We will use Ann Arbor, Michigan as an example of how to use climate data. Use Figure 1 to fill in the chart below and to practice analyzing graphs.

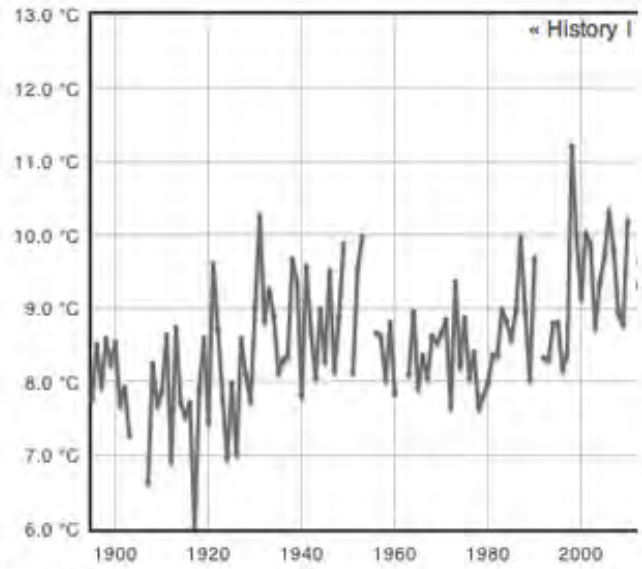


Figure 1: Average annual temperature in Ann Arbor from 1900 to 2010.

Year of Observations	Temperature (in Celsius)
Average Annual Temperature for 1900	8
Average Annual Temperature for 2000	9

Part 2: Is average temperature changing over time?

Students look at the same climate data, but with a trend line calculated and superimposed over the data.

Below is the same graph with a trend line. A trend line is used to show the general pattern or direction of a series of data. The trend line in Figure 1 shows the average annual temperature in Ann Arbor from 1900 to 2010. The change in average annual temperature per century can be calculated by finding the difference between the temperature at the beginning of the century and the temperature at the end of the century. Finding this difference can help us determine long-term changes to climate. Use Figure 2 to determine the average annual temperature change in Ann Arbor between 1900 and 2000, and enter it here:

More than 1 degree Celsius

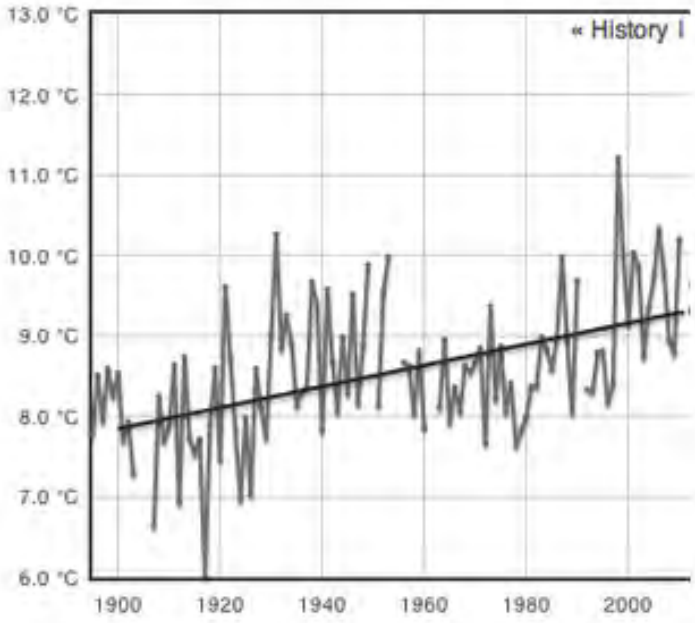


Figure 2. Average annual temperature in Ann Arbor from 1900 to 2010 with trend line.

Part 2: Is average temperature changing over time?

Students compare trends in one place, with trends in other places throughout the world.

Remember that these are data for Ann Arbor, Michigan only. Let's compare this trend to other cities across the world. Scroll down on the Local Climate page of Weather Underground until you see a map. The images below show an example. Type the name of the first city on the table (Fargo, North Dakota), and click "Search" (left image). Next, click the orange temperature icon beside the city (center image). Then click "View This Station" (right image).

Look for the "Show post-1900 trend" box at the bottom of the graph and make a note of the value provided. For Fargo, North Dakota, for example, it says average temperature increased 1.6 degrees Celsius between 1900 and 2000.

Repeat these steps for all of the cities listed below and a place of your choosing.

Cities	Name of City You Chose	Change in Average Temperature per Century
Fargo, North Dakota	Fargo, North Dakota	1.6
Fairbanks, Alaska	Fairbanks, Alaska	2.9
Helsinki, Finland	Copenhagen, Sweden	1.5
Your choice of U.S. city	Boston, MA	1.7
Your choice of U.S. city	Tucson, AZ	1.9
Your choice of city outside the U.S.	Nome, Alaska	2.2

Calculate an average of these six temperature values in the table, and write it here:

1.96

Now let's compare the average temperature of the six cities to the global average temperature trend shown in Figure 3. Are the results the same or different? Why do you think this is the case?

The results are different. I found an average of 1.96 degrees difference. The graph shows 0.7 degrees difference. I think it is because I chose mainly northern cities, where temperatures are expected to change more.

Part 2: Is average temperature changing over time?

Students answer the scientific question: Is one cold winter evidence of changing climate?

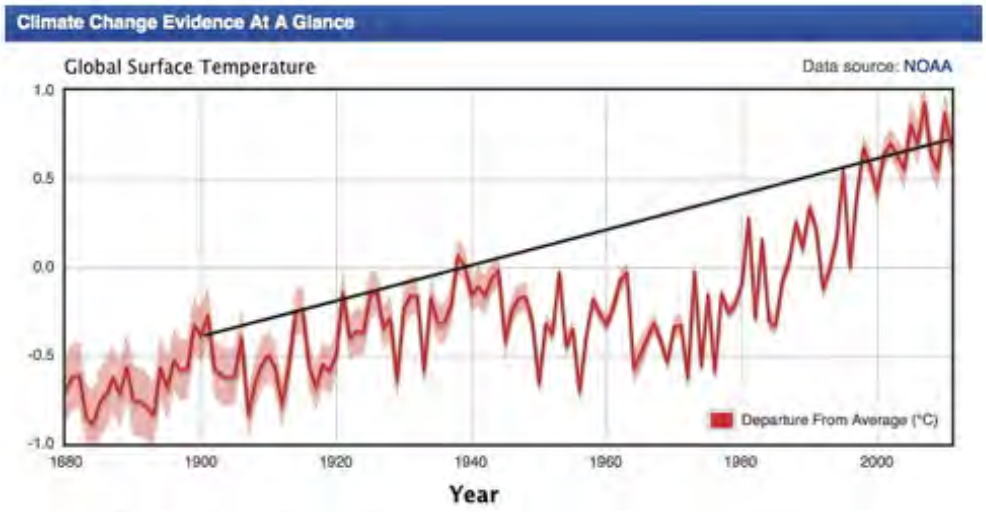


Figure 3: Post-1900 trend: 0.7 degrees Celsius per century

Use the information in Figure 3 to answer the scientific question below:

Scientific Question: *Is one cold winter evidence of changing climate?*

My Explanation

Claim: Hint

No, one cold winter is not evidence of changing climate.

Reasoning: Hint

One cold winter is not enough data to show that climate is changing. Climate is an average over longer periods of time.

Evidence: Hint

1. Climate is an average pattern over longer periods of time than one year.

2. One cold winter is not enough data to understand climate.

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Part 3: Does a small change in temperature matter?

This lab uses the freezing/melting point of stearic acid to show that even a small increase in temperature can have an impact. Because this comparison does not address phase change, it is important to emphasize that the impact of a degree change depends on what is being affected. Students are likely to think that all polar icecaps will melt. This will happen to a small extent, but challenge students to think beyond phase changes, such as the potential dangers to terrestrial and marine wildlife.

Teacher Lab Directions:

- Fill three beakers with 500 ml of tap water. Add a thermometer to each beaker; wait several minutes until the water temperature is the same in all 3 beakers.

Name: _____ Jeremy_____ Period: ___2___ Date: ___Oct. 17, 2012___

Laboratory: Stearic Acid

Introduction:

Can a few degrees matter? We've seen that global temperature is increasing over the past century, but only by a small amount. We want to investigate if a small amount of change in temperature can make a difference by looking at a pure substance, stearic acid. Stearic acid is a common saturated fatty acid that is used to produce soaps, detergents, and shampoos. We will use it to illustrate temperature change and then apply the findings to potential climate change.

Purpose:

To determine what happens to temperature when the pure substance, stearic acid, is added.

Materials/Equipment

- Thermometer
- Test tube containing stearic acid
- Test tube rack
- Timing device (stopwatch, clock, etc.)
- Boiling water bath

Procedure:

1. Heat the test tube containing stearic acid in the boiling water bath until the acid is completely melted, and reaches a temperature of about 90°C.
2. Remove the sample from the water bath. Stir the stearic acid constantly with the thermometer while it is cooling and record its temperature once every minute in the data chart below.

Part 3: Does a small change in temperature matter?

Encourage students to make careful observations about what is happening to the stearic acid at each temperature.

Data Chart

Time (min)	Temp (°C)	Observation
0	95	It is a clear liquid
1	93	It is still all clear and a liquid
2	89	It is a clear liquid. It is easy to stir the thermometer
3	86	No change
4	82	No change
5	76	No change
6	74	No change
7	72	No change
8	70	White crystals begin to form and fall to the bottom
9	70	More white crystals form The white crystals are "raining" down
10	70	Half the substance looks like white, solid crystals. The rest is still clear.
11	70	Some of the substance is stuck on the side of the test tube and the thermometer is kind of "stuck." The substance is hard to stir.
12	70	Everything in the test tube is a white solid
13	68	There is no change, the substance is a white crystalline solid
14	65	Some stearic acid that got on the top of the thermometer feels waxy
15	61	No change
16	57	No change
17	55	No change

3. Closely observe the test tube. When you notice a change in temperature in the test tube, write down your observation in the space below. A good observation includes the temperature, the state of the stearic acid, and a description of what it looks like. You will need to make four observations at different times. The first one is done for you as an example.
4. Continue this process until the temperature of the stearic acid cools down to 55°C.

Part 3: Does a small change in temperature matter?

Once students are done analyzing their observations, you can end with a class discussion. Potential questions:

- Did you get the order correct?
- Can you tell the difference in temperature?
- How you think a degree change can have an impact on climate/environment?

Observations:

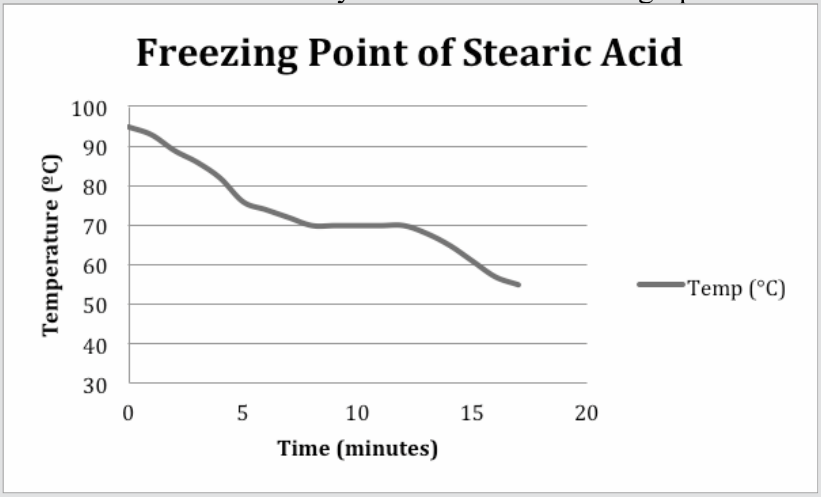
1. At room temperature, the stearic acid is a white solid that looks like it has some crystals in it.
2. When the crystals started to form the temperature is 70°C. It stayed that temperature until all the substance was a white solid. Then, it started to cool again.
3. The stearic acid started as a clear liquid and when it cooled it was a while, crystalline solid.
4. When the stearic acid is a white solid, it feels waxy.

Analysis:

1. In this analysis you will be graphing temperature and time. On the graph paper, label the axes as follows: x-axis (horizontal) = time, and y-axis (vertical) = temperature. Think about the dependent variable – Does time depend on the temperature of the stearic acid? Or does the temperature of the stearic acid depend on the time it has been cooling?

The temperature of the stearic acid depends on the time that it has been cooling. Time is the independent variable and temperature is the dependent variable.

2. Plot the data from your Data Chart on the graph.



3. Look at the graph. What impact does temperature change have on stearic acid?

Initially, as the temperature decreased the stearic acid remained as a liquid. When it cooled and began to form white crystals it was 70°C. It stayed at this temperature because it is the melting point/freezing point of stearic acid. It remained 70°C until all the stearic acid was a white crystalline solid. Then, the temperature began to decrease again.

4. Do you think a small amount of temperature change could have an impact on habitat or ecosystems? Why or why not?

Yes, a small amount of temperature change can have a large impact on a habitat or ecosystem because a few degrees matter. A few degrees warmer can cause ice to melt, food sources to change, and animals to migrate to different geographic locations.

Part 3: Does a small change in temperature matter?

After the stearic acid lab, students revisit patterns in global temperature in the last century and answer several questions.

Lesson 4 Part 3: Does a small change in temperature matter?

In the previous activity you learned that the average global temperature is changing a little bit. But do tenths of a degree really make a difference?

This activity begins with a demonstration. You will watch your teacher conduct a laboratory to see if tenths of a degree matters.

Are there temperature trends in the past century?

Let's take a look at Figure 3 again (below). What other information we can gather from it? During what time period is the majority of global temperature increase happening?

Since 1960.

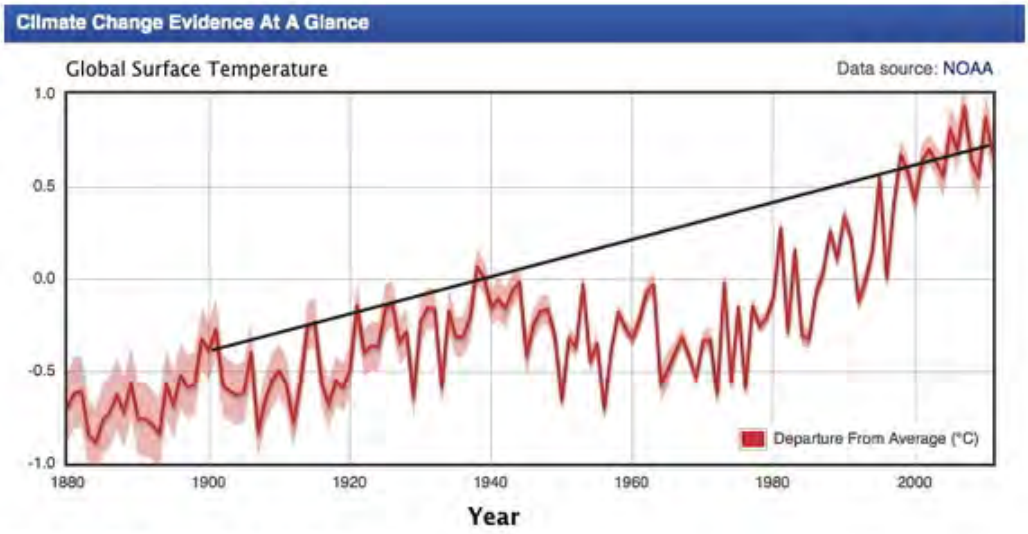


Figure 3: Post-1900 trend: 0.7 degrees Celsius per century

What do you think are some causes of this increased change?

Human activity.

Extension Activity: To further explore how the environment will be impacted by temperature increase, show chapters "Degree One" and "Degree Two" of the video Six Degrees Could Change the World. These two chapters will help students visualize many of the potential impacts of climate warming. The other chapters in the video are addressed, in part, in the remainder of the curriculum.